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MILITARY

JAPAN MAY GET U.S. ANTIMISSILE DEFENSE

OW130331 Tokyo KYODO in English 9322 GMT 13 Jul 82

[Text] Tokyo July 13 KYODO--The government will study the possibility of acquiring an American antimissile system to protect Maritime Self-Defense Force (MSDF) ships at sea, according to a position paper adopted by the Cabinet Tuesday. Another position paper adopted at the same time states that the government is "interested" in military reconnaissance satellites, but has no plans at present to develop them.

Both papers were prepared in response to questions submitted by Yutaka Hata, an opposition Shinsei Club Upper House member, on the defense of Japan's sealanes and the lessons for Japan of the Falkland Islands dispute.

The American Aegis command and control system is being developed by the Pentagon to counter the threat of antiship missiles, which proved so devastating to British warships during the Falklands fighting.

The Soviet Union is believed to be deploying long-range backfire bombers armed with antiship missiles in a maritime strike role in both the Pacific and Atlantic Oceans.

The Aegis system uses SM-2 standard missiles, a sophisticated fire control system and a multifunction array radar system capable of tracking multiple targets to intercept incoming missiles. The computerized system is to be installed for the first time on the 9,055-ton missile cruiser U.S.S. Ticonderoga, scheduled for launching next January.

According to the Cabinet position paper, the Defense Agency is studying acquiring Aegis missile destroyers to meet the aerial challenge to sealand defense. As currently envisaged, the ships would weigh in at about 6,000 tons, and would be laid down around 1987. However, the position paper states that it will "take some time" to reach a decision, and says it is not now possible to discuss the performance, displacement, number of ships or construction costs for such a program.

Meanwhile, in response to questions on the lessons of the Falkland Islands dispute, the Cabinet said it was interested in military surveillance satellites as a "valuable means of gathering information."

Unconfirmed reports have said that both U.S. and Soviet spy satellites played an important role in the fighting between Argentina and Great Britain, with both nations receiving informaion of enemy naval deployments obtained from tellite pictures. Such satellites, represented by the Soviet Cosmos series and the American Big Bird satellites, are launched into low orbits about 200 miles up from which they can take high-resolution pictures of surface objects. Film is often returned to the earth in special reentry capsules.

France is known to be developing its own independent space surveillance capability, and Japan's ruling Liberal-Democratic Party (LDP) Space Development Committee has itself proposed the launching or reconnaissance satellites to follow developments on the Soviet-occupied northern islands.

In its position paper, the Cabinet termed information-gathering "extremely important" to Japan's so-called "exclusively defensive defense" posture. However, it stated that there are presently "no plans" for a satellite program, reflecting a 1969 Diet (Parliament) resolution limiting Japanese space development to "peaceful purposes."

Nonetheless, the LDP called in June for allowing military space development for defensive purposes "within the framework of the Constitution."

Though a Defense Agency spokesman said no "concrete studies" of the issue are underway, Japan's pentagon is said to be collecting publicly available material on surveillance satellites for information purposes. Even if the legal problems could be overcome, there would remain numerous other obstacles to an independent Japanese space surveillance capability.

The low orbit required for precision photography limits the operational life of military satellites to a year or less, and several must be kept in orbit to provide continuous coverage of a given area. While it is estimated that such satellites would only cost some yen 5 billion each when mass produced, experts say the necessary R and D, launch facilities and other preparations could raise the cost of getting a military satellite program off the ground to about yen 100 billion.

CSO: 4120/340

ECONOMIC

TRENDS, PROBLEMS IN JAPANESE AGRICULTURE

Tokyo NRI SEARCH in Japanese Jun 82 pp 14-15

[Summary] In October 1980 the Agricultural Policy Deliberation Council submitted a report called "Basic Trends in Agricultural Policy in the 80's." The council outlined basic policies which included balancing supply and demand by means of a price policy through the market mechanism, improvement of productivity by encouraging core farmers, and the maintenance and strengthening of self-sufficiency in food. Responding to this report, there were many opinions from various industrial sectors regarding Japanese agricultural reforms. Some of them were:

1. Avoid overprotective aid from the government and seek spontaneous efforts from farmers for agricultural reforms.

2. Carry out fundamental changes and rationalization of the agricultural budget.

3. Enlarge the scale of management and improve productivity.

4. Introduce market mechanisms and try to match domestic prices to international ones.

5. Establish more advanced agricultural technology and strive to export rice.

One problem facing Japanese agriculture today, especially in the type of land used for farming, is the improvement of productivity by enlarging the scale of management. However, several problems remain to be discussed first.

1. The Method

To promote the turnover of farmland by leasehold, the law has been adjusted to emphasize the right of the lender. This would tend to weaken the foundation of land management as practiced by the lessee. The lessee is unable to make large-scale investment, such as buying large machinery to improve productivity, unless he can be guaranteed the right to lease the land on a permanent basis.

2. Expansion

The enlargement of farmland and the improvement of productivity would generally lead to an expansion of markets and to large-scale reorganization of producers. Unfortunately, in the case of the type of land used for farming, one eager producer's action could block expansion.

3. The Effect of Increased Farmland

Even if the scope of farmland based on leasehold expands, the cost of productivity might not be lower than expected. If low-cost productivity were achieved, the landowner would probably raise the rent and the lessee would have to go along with this if he had made a large investment. If there were more lenders than lessees, the power of lenders would be strengthened and they would absorb the profit from the improvement in productivity.

The effect of large-scale management on farmland has not been very great. The main reason for his ineffectiveness is that large-scale management was considered only a "step" to improve productivity, while the means to "motivate" productivity is incomplete. The most basic way to motivate productivity is to enlarge markets. "Export of rice" is probably an effective solution for this purpose. However, it would be normal to consider expanding the domestic market before going to the overseas market.

Rice is overproduced in Japan. The self-supply ratio of grain is 33 percent out of 100, and, especially the feed grain ratio is low. The difference between domestic and international prices for feed grains is quite large, but if Japan could narrow this gap by improving productivity, there is the possibility that Japan could cultivate new markets in the future. The government could also stimulate production by increasing the amount of its purchases when the price falls. This would eventually lead to the expansion of markets and could promote distribution in the most positive way. The most important thing is to take concrete measures for the "improvement of productivity" and the "expansion of markets."

It is worthwhile for Japanese agriculture to refer to the present agricultural situation in advanced nations and to learn about the growing processes of Japanese industries. However, it is necessary for it to find the direction for long-term prospects in line with Japanese climate and the special characteristics of Japanese agriculture.

CSO: 4105/151

ECONOMIC

PROTECTION FOR AGRICULTURAL AND LIVESTOCK PRODUCTS, FOOD INDUSTRY

Tokyo NRI SEARCH in Japanese Jun 82 p 18

[Excerpt] The food industry depends heavily upon raw materials and, the degree of mutual dependency between the food industry and raw materials producing sector including agriculture is high. In the case of primary processors, such as flour milling, livestock feed, edible oil and sugar refining, the cost of raw materials accounts for 80 percent of total costs. The cost of processed foodstuffs which have a big demand in the market fluctuates due to the high cost of primary processed products and the use of perishable food whose supply is unstable.

At present the domestic supply capacity of raw materials is insufficient and we have to depend on overseas markets (90 percent of wheat and soybeans, 70 percent of raw sugar and livestock feed). However, various import restrictions are placed on foreign products in order to protect Japanese agriculture and at the same time to sustain a reasonable self-sufficiency ratio in Japan. Therefore, the prices of imported materials necessary for production are kept high compared to international price levels. Under the Food Control System, wheat is sold to producers by the Food Agency without any reference to the international market price. This practice prevents millers from free pricing. On the other hand, the Price Supporting System is applied on edible meat and sugar and the Tariff Quota System has been adopted for imported natural cheese, beer fermentation, biscuits and candies. These systems became the core elements in preventing cost reductions for raw materials and also keep the price of products high. They could prevent Japanese goods, which lack international competitive power, from being taken over by low-price imported goods in the domestic market.

CSO: 4105/152

PLANT COMPLETED TO PRODUCE SATELLITES

OW041006 Tokyo KYODO in English 0714 GMT 4 Jul 82

[Text] Tokyo July 4 KYODO--Nippon Electric Co. (NEC) said Sunday it had completed Japan's first plant for mass production of satellites in Yokohama. A spokesman for Japan's largest semiconductor maker said the company had invested yen 2.5 billion (dollar 9.8 million) in construction of the five-storied plant covering 6,000 square meters. Ryuji Kuroda, space development manager of NEC, said the plant is capable of simultaneously producing 4 major satellites each weighing up to 1 ton.

The plant consists of the five latest facilities--those for satellite assemblying, three axial attitude control test, radio wave interference test, research and development of equipment for loading satellite and antenna research and development.

The plant will shortly start assemblying Japan's first marine observation satellite 1 (MOS 1) now under development using Japan's own technology, the spokesman said.

According to Kuroda, NEC has already developed 15 or 23 satellites so far launched by Japan--12 for scientific purposes and 11 for practical application. Kuroda said the engineering test model of the MOS 1 will be completed by this fall.

Mitsubishi Electric Corp., Toshiba Corp. and Fujitsu, Ltd, are developing a three axial attitude control device and solar cell panel and sensor for the MOS 1, but NEC will be in charge of the most important part--the final assembly, he said.

Kuroda said NEC also hoped to win an order for the second generation major communication satellite "CS3," since NEC's transponder is used not only for Japan's communication satellites but also for the International Communication Satellite (Intelsat). Both NEC and Mitsubishi Electric are competing fiercely for the CS3 due to be launched in 1988.

Nippon Telegraph and Telephone Public Corp. is also studying the possibility of launching a major communication satellite weighing 14 tons.

CSO: 4120/339

SURVEY MADE ON INDUSTRIAL TECHNOLOGY LEVEL

OW101148 Tokyo KYODO in English 1012 GMT 10 Jul 82

[Text] Tokyo July 10 KYODO--Japan has caught up with the United States in many fields of industrial technology but still lags behind in basic scientific research, according to a government survey released Saturday. The findings compiled by the government-operated Agency of Industrial Science and Technology showed that Japan is notably behind the United States in computer software, biochemistry and aerospace technologies. "More creative work is needed in basic research on such things as the design and development of new materials," the report said. "Research is the foundation of Japanese industry."

The survey, conducted last June, focused on 186 industrial products manufactured both in the United States and Japan, some 600 senior researchers were asked to give their personal evaluation of technology levels between the two countries. The Japanese researchers said the United States was superior in 72 products, as against 54 for Japan. They said the two countries were about equal in the remaining 60 items.

Survey respondents said Japan has surpassed the United States and Western Europe in conventional technologies such as video tape recorders, refrigerators, shipbuilding, automobiles and polyvinyl products.

However, the list of high-tech products in which Japan is lagging includes aircraft, communications satellites, and gas turbines for power generation.

In particular, the respondents said, Japan is slow in developing pharmaceutical products, including antibiotics and anticancer drugs, and in semiconductor laser beams, and computer programs.

"The results of the survey show Japan is particularly behind the United States in basic research into new products and industrial design," the agency said.

The only high-tech products in which the Japanese researchers felt Japan was superior to the United States were optical fibers, special steels, vinyl chloride, synthetic dyes and ceramics, the survey said.

CSO: 4120/339

MICROWAVE ABSORBENT COMPOSITE FERRITE DEVELOPED

Tokyo KINO ZAIRYO in Japanese Jan 82 pp 38-46

[Article by Ken Ishino, chief, and Kenichi Ichihara, of Microwave Department, TDK Electronics Co., Ltd.]

[Text] 1. Introduction

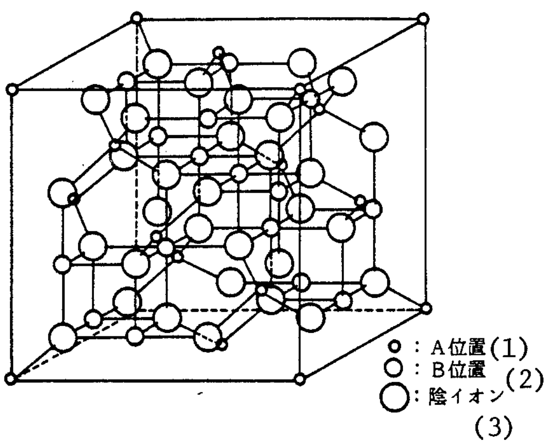
It is very difficult to define the term composite ferrite in a strict sense. We shall discuss it here from the viewpoint of a heterogeneous substance, excluding for now the microscopic composites such as a solid solution (for example, Ni-Zn ferrites) and sintered compounds. It is treated mainly in the sense of a composite material composed of nonmagnetic compounds in which ferrite powder is dispersed. The functions demanded of composite ferrites having a microwave absorption characteristic will be explained, and new research trends will be discussed. Conventionally, the important use of microwave absorbers has been for the absorbent walls of a microwave darkroom.[1-4] As an absorber, it is constructed to hold carbon powder with an appropriate material (for example, foam urethane); it has many characteristics such as light weight, and it demonstrates superior properties over a wide band. On the other hand, in order to obtain the microwave absorption characteristic considered effective as a general absorber, it is necessary to be of a size corresponding to approximately one-fourth the wavelength of the lower band frequency in use, and there is a limit to its conditions for use with respect to size.

In the meantime, demands for thin, wideband microwave absorbers have been increasing recently as a countermeasure to prevent secondary radiation in outdoor microwave measurements and to prevent false radar images generated by a ship's mast, etc.[5] As one of these materials, a new magnetic radiowave absorber is being reevaluated in which the magnetic relaxation phenomenon of ferrite is of interest.[6,7] In the past, it was believed that the only example of composite ferrites, which are nonmagnetic compounds in which ferrite is dispersed, is the so-called "rubber magnet," in which a permanent magnet is used.[8] Recently it was discovered that composite rubber ferrite using soft ferrite has a large magnetic attenuation in the microwave band, and it demonstrates a superior characteristic that fulfills the above-mentioned demand as a microwave absorber for this band and so it is attracting a great deal of attention.[9,10]

2. Various Characteristics of Composite Ferrites

A ferrite is generally an oxide whose chief component is ferric oxide (FE_2O_3). Industrially, it is an oxide magnetic compound which demonstrates strong magnetism at about room temperature. Ferrites can be classified into hard ferrites, used as magnets, and soft ferrites, frequently used as the magnetic core of coils, etc. Soft ferrites are ferrites that can be shown by the general formula $M^{2+}O.Fe_2O_3$

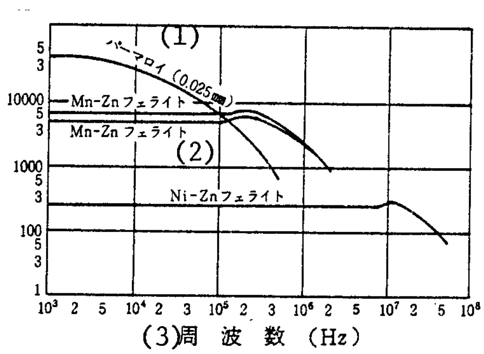
Figure 1 shows the crystalline structure of ferrites. As is clear from the diagram, oxygen ions are positioned coordinately around iron or divalent metal ions in 4-coordination or 8-coordination. The magnetic properties of ferrites vary with the kind of divalent metal ion, the relative position of iron, and the divalent metal ion. Today, several hundred ferrites with varying magnetic characteristics are being used as electronic materials for various purposes. The characteristics of soft ferrites may be expressed by permeability, magnetic flux density, and anisotropy constant, among other things; their respective characteristics are interrelated. If consideration is limited to the ferrites used as microwave absorbers, however, the characteristic of the microwave absorbers is dependent upon the magnetic loss of ferrite. Therefore, we shall discuss here mainly the magnetic-loss characteristics of ferrites--that is, the real number portion (permeability in the ordinary sense) and imaginary number portion (loss term) of the complex permeability in which magnetic loss is also taken into consideration ($\dot{\mu}=\mu'-j\mu''$).



Key:
(1) position A
(2) position B
(3) negative ion

Figure 1. Crystalline Structure of Ferrites[11]

Since ferrites are oxide magnetic materials, they are characterized by the fact that their specific resistance is high compared to metal magnetic materials. In other words, as opposed to about $10^{-6}\Omega\cdot cm$ for metal magnetic materials, the specific resistance of ferrites is 10^2-$10^7\Omega\cdot cm$. Consequently, when they are used as a magnetic core material, it is possible to obtain a magnetic core with virtually no eddy-current loss, provided a type of ferrite is selected according to the frequency used. Figure 2 shows the frequency characteristics

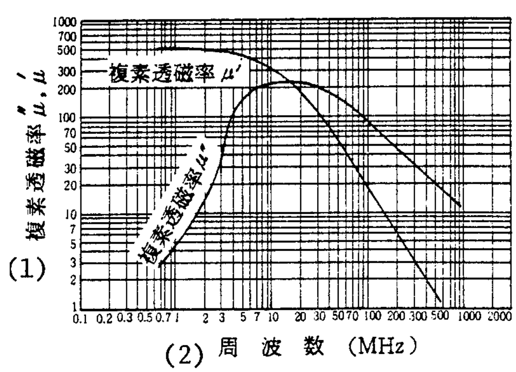


Key: (1) Permalloy
(2) Ferrite
(3) Frequency

Figure 2. Permeability of Ferrites and Permalloy

of the real number portion of complex permeability (μ', simply called permeability hereafter) of Permalloy (metal magnetic material), Mn-Zn ferrite, and Ni-Zn ferrite. The permeability of Permalloy with a low specific resistance decreases with frequency. This is attributable to eddy current. On the contrary, almost a constant permeability value is shown by Mn-Zn ferrite, to approximately 10^5 Hz, and Ni-Zn ferrite, to approximately 10^7 Hz, after which a relaxation type of attenuation caused by magnetic resonance (discussed later), determined mainly by chemical compositions, is observed.[15]

A ferrite microwave absorber has been developed, taking note of this relaxation phenomenon. Figure 3 shows the frequency characteristics of complex permeability of Ni-Zn ferrite, which is in use today to prevent TV ghosts in the 100-MHz band. As μ' decreases, a large magnetic loss (μ") is observed in the 100-MHz band.[12,13] When a ferrite or composite ferrite is used as a functional material with a microwave absorption characteristic, this μ'μ" movement--that is, the frequency characteristic of the complex permeability--becomes the basic characteristic.[16,17] On the other hand, the so-called composite ferrite with ferrite mixed in rubber or plastic by dispersion shows a marked deterioration of permeability, and in the past it was not considered as a magnetic core material.



Key: (1) Complex permeability
(2) Frequency

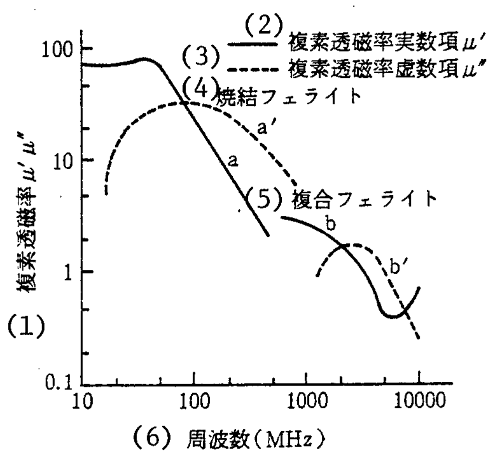
Figure 3. Frequency Characteristics of Ni-Zn Ferrite

Table 1. Changes in Magnetic Characteristics Associated With Mn-Zn Ferrite Composite Formation

	Sintered ferrite	Composite ferrite
Permeability (1 KHz)	2,500	15
Saturation flux density (H=150 Öe)		

A 50 percent volume ratio of ferrite with mean particle size of 3μ was mixed in chloroprene rubber for this composite ferrite

Table 1 shows an example of the characteristics when Mn-Zn ferrite is combined with rubber. We cannot find here the characteristics as a magnetic core material that uses permeability. On the other hand, when the frequency characteristic of complex permeability is examined as a microwave absorber, it has been proven that composite ferrite shows a characteristic behavior in the microwave bands above 1,000 MHz. Figure 4 shows a typical example using Ni-Zn ferrite; "a" is a sintered ferrite, and "b" is a composite ferrite with a rubber mixture. In the case of sintered ferrite, magnetic resonance (discussed later) is observed in the vicinity of 100 MHz and a large loss is shown, whereas in the case of composite ferrite, the same ferrite powdered and mixed with rubber, magnetic resonance is observed in the vicinity of 3,000 MHz and a large attenuation is shown.[18]



Key:
(1) Complex permeability
(2) Complex permeability real number term
(3) Complex permeability imaginary number term
(4) Sintered ferrite
(5) Composite ferrite
(6) Frequency

Figure 4. Changes in Complex Permeability Associated With Conversion to Composite Ferrite

This phenomenon allows us to anticipate the fact that a superior microwave absorption characteristic will be demonstrated in the microwave band because of the characteristic obtained by making the soft ferrite a composite. As a result, composite ferrites have been reevaluated in recent years as microwave absorption materials in the microwave band.

2.1 Ferrite content and magnetic characteristic

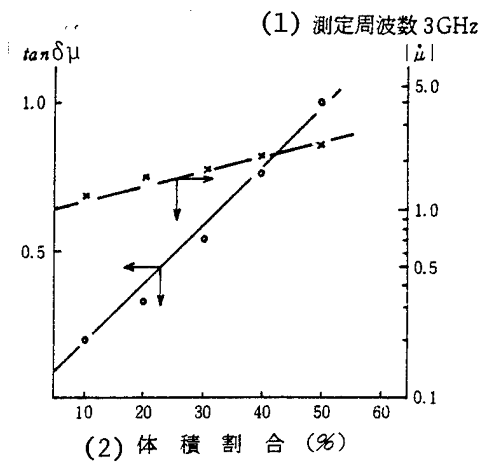
Regarding the magnetic characteristic of a composite ferrite comprising a mixture of soft ferrite and rubber or plastic, Birks performed an experiment earlier using α-Fe_2O_3 and demonstrated the fact that $|\dot{\mu}|$ and $\tan\zeta\mu (= \frac{\mu''}{\mu'})$ obey the mixed logarithmic equation of Lichitnecker shown below.[19]

$$\log|\dot{\mu}| = V \log|\dot{\mu}_a| \qquad 1$$

$$\tan\zeta\mu = V \tan\zeta\mu \qquad 2$$

where the suffix a signifies the characteristic in α-Fe_2O_3. Therefore, when these equations are used, a certain degree of speculation is possible regarding the magnetism for a composite case. However, as discussed later, it will differ by the mean particle size of the ferrite, and it is necessary to confirm it finally by experimentation.

Figure 5 shows the relationship of mixed ratio and magnetic characteristics for Mn-Zn ferrite. As is clear from the graph, the relationships of the volume mixture ratio to $|\dot{\mu}|$ and $\tan\zeta\mu$ reveal the fact that they satisfy Lichitnecker's equations. These relationships indicate that the magnetic loss of composite ferrite ($\tan\zeta\mu$) is proportional to the volume mixture ratio, and in the case of a microwave absorber designed by focusing on the magnetic loss term (microwave absorber for the prevention of microwave leakage), it is necessary to increase the mixture ratio of ferrite.



Key: (1) measured frequency
(2) volume ratio

Figure 5. Relationship of Mn-Zn Ferrite Volume Ratio to $\tan\delta\mu$ [error for $\tan\zeta\mu$?] and $|\dot{\mu}|$

We shall consider here the mixing ratio in the case of a ferrite and resin or rubber mixture. The ferrite used for a composite ferrite is generally a powder made by pulverizing sintered ferrite. When sintered ferrite is pulverized using a ball mill or hammer mill, a powdery substance with a mean particle size of less than 10μ is obtained. Soft ferrites have a cubic crystalline structure, as mentioned before, but pulverized powder takes a relatively random form, such

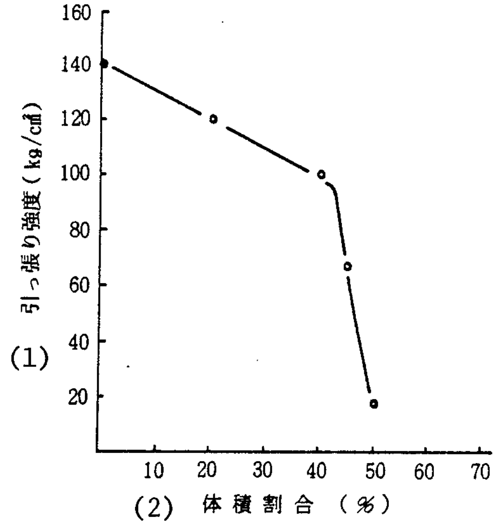
as seen with crushed rocks. This powder has no complex surface structure and does not change with pressure or shearing stress during mixing, and mixing with resin or rubber can be done relatively easily. When such a powder is mixed into rubber or resin and diffused, how much may the mixing ratio be increased? In the case of mixing a powder with liquid, the particles of powder are generally considered spheres, and the ratio of the volume of spheres to the volume of spaces when they are packed in the maximum density is considered the limit of the mixing ratio.[20] When this sphere model is used, the ratio of the volume of spheres to the volume of spaces is approximately 6:4.

Consequently, if we assume that the particles of powder are spherical, the upper limit of the mixing ratio is the volume ratio, which is 60 percent. Naturally, when the shape of the powder particles is not spherical, this value is different. Also, when the size of the powder particles is irregular, the value is expected to be greater than the above ratio (in the case of the above-mentioned model, for example, if there are spheres small enough to fill the spaces, the volume ratio held by the spheres increases). In the case of soft ferrites, it is empirically possible to mix up to a volume ratio of 70 percent. This is believed to be due to the fact that the shape of the particles is not spherical, and there is a certain degree of distribution of the particle sizes.

However, the mixing ratio that is industrially feasible is lower than the above value. The reasons are: (1) mixing takes a considerable amount of time, and (2) mechanical properties deteriorate. The second reason is believed to be due to the fact that the powder particles are not completely coated with resin or rubber because the mixing ratio is at the upper limit, and the bonds between the particles become weaker. In addition, there is virtually no interaction between the particles and resin or rubber, and the bonding between the particles and the resin is weak. Figure 6 shows the relationship of the volume mixing ratio and tensile strength in the case of Mn-Zn ferrite powder mixed and dispersed in chloroprene rubber. It reveals the fact that the strength rapidly deteriorates as the volume ratio increases higher than 45 percent. This indicates that there is almost no interaction between the ferrite particles and chloroprene rubber. This is believed to be due to a physical lack of a complex surface structure and chemical activity because it is a stable oxide.[21] Owing to the above reasons, the mixing ratio for mixing and diffusing ferrite powder in resin or rubber is limited to render 70 percent in volume ratio.

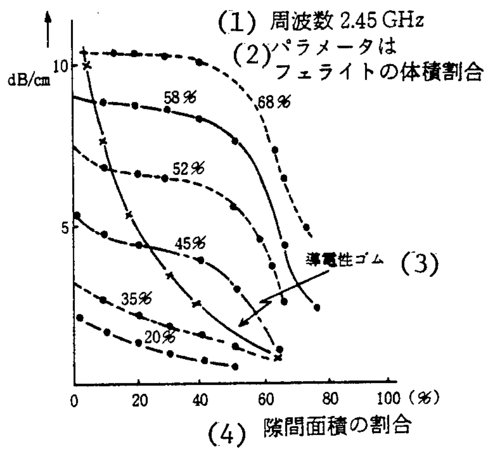
In the case of a microwave absorber (an absorber used for prevention of microwave leakage), as previously mentioned, an increase in the mixing ratio of ferrite is required, and a way to upgrade the electrical characteristics without reducing the mechanical properties is being sought by adjusting the particle size and distribution of particle sizes and the use of surfactants, etc. A typical application example of a microwave absorber using only the magnetic loss of composite ferrite is the gasket for prevention of microwave leakage in a microwave oven. For this purpose, a composite ferrite with Ni-Zn ferrite or Mn-Zn ferrite mixed in rubber or plastic is used.

In the case of the composite ferrite microwave absorber, it is not only superior in its microwave absorbing effect, but it also has a microwave converging effect, as shown in Figure 7. Thus, unlike the conventional conductive rubber



Key: (1) tensile strength
(2) volume ratio

Figure 6. Tensile Strength of Composite Ferrite Formed by Mixing and Diffusing Mn-Zn Ferrite in Chloroprene Rubber



Key: (1) frequency
(2) parameter is the volume ratio of ferrites
(3) conductive rubber
(4) ratio of space volume

Figure 7. An Example of Microwave Converging Effect

gaskets, a completely sealed state is not required, and the microwave-leakage-prevention effect is not lost even when a slight gap occurs. As shown in Table 2, various kinds of composite ferrites are now in practical use as radiowave leakage preventive absorbers in the microwave band, including those for microwave ovens.

Table 2. Composite Ferrite Microwave Absorbers Used for Microwave Leakage Prevention (from TDK Catalog)

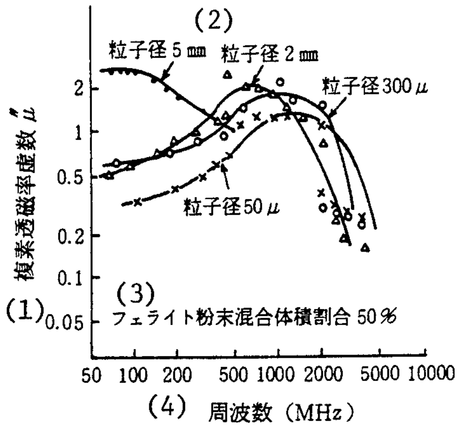
Material	IR-B006	IR-B006PE	IR-B006P	IR-B006M	IR-B005H	IR-B005S
Highlight	Flexible	Flexible	Rigid	Rigid	Hard High temperature resistance	Flexible High temperature resistance
Frequencyrange	500MHz and up	500MHz and up	500MHz and up	500MHz and up	500MHz and up	500MHz and up
Basic composition	Ferrites in chloroprene rubber	Ferrites in polyethylene chloride rubber	Ferrites in polypropylene resin	Ferrites in polyamide resin	Ferrites in unsaturated. polyester	Ferrites in silicon rubber
color and surface	Black smooth	Black smooth	Black smooth or mat	Black smooth or mat	Black smooth or mat	Black
Cover		Coverless	Coverless	Coverless	Coverless	
Operating temperature	Up to 100℃	Up to 100℃	Up to 65℃	Up to 150℃	Up to 200℃	Up to 300℃
Manufacturing process	Extrusion Compression	Extrusion	Injection	Injection	Compression	Compression
Attenuation at 2.45GHz	12 dB/cm and greater	12 dB/cm and greater	12 dB/cm and greater	12 dB/cm and greater	12 dB/cm and greater	12 dB/cm and greater
Oil resistance	Good	Good	Good	Good	Good	Good
Spilled food resistance	Good	Good	Good	Good	Good	Good
Density	3.3	3.2	2.9	3.0	3.4	3.3
Tensile strength	10 kg/cm^2 and higher	10 kg/cm^2 and higher	10 kg/cm^2 and higher	10 kg/cm^2 and higher	10 kg/cm^2 and higher	10 kg/cm^2 and higher
Flexial strength	N/A	N/A	1.5 kg/mm^2 and higher	1.5 kg/mm^2 and higher	1.5 kg/mm^2 and higher	N/A

2.2 Frequency Characteristics of Complex Permeability

As has been described, a magnetic relaxation phenomenon of composite ferrites is observed in the microwave band, and a large attenuation occurs. The magnetic losses conceivable in the high-frequency band include various kinds of losses such as hysteresis loss, eddy-current loss, etc. In the case of composite ferrites having a large specific resistance, a relaxation type of loss attributable to magnetic resonance is believed to be the major loss. Generally, the frequency at which magnetic resonance occurs, ω, is given by $\omega=\partial Hi$. [$\omega(=2\pi f)$: resonance frequency, Hi: internal magnetic field (anisotropy field), ∂: gyromagnetic ratio (constant)]. According to this equation, as Hi changes, the resonance frequency changes, and it is possible to obtain magnetic resonance in the desired frequency by controlling Hi.

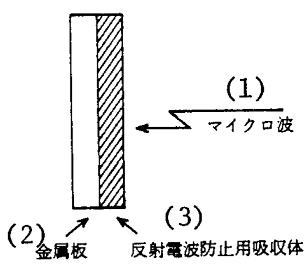
The internal magnetic field, Hi, of a composite ferrite changes depending on the type of ferrite, the particle size, the mixing ratio, etc. Figure 8 shows the frequency characteristic of μ'' when the particle size of Mn-Zn ferrite is varied from 50μ to 5mm. Resonance frequency also changes depending on particle size. In addition to its use as a microwave leakage preventive absorber, in which magnetic attenuation alone is of interest, a microwave absorber may be considered in designing an antireflective microwave absorber that suppresses microwave reflection in a structure. Particularly in recent years, antireflective microwave absorbers are being reevaluated in connection with the development of microwave communications.[22] Along with the required loss of microwave due to absorption in the required frequency range, this type of microwave absorber needs to satisfy the condition that the microwaves not reflect off the surface

of the microwave absorber in the frequency range (electrically, impedance of free space is equal to the surface impedance of the microwave absorber). In order to satisfy this condition, attention should be drawn not only to the μ'' size in the loss term of complex permeability, but also to the frequency characteristic of complex permeability including μ'.



Key: (1) complex permeability imaginary number, ∂"
(2) particle size
(3) ferrite powder mixing volume ratio
(4) frequency

Figure 8. Relationship Between Particle Size and Magnetic Characteristic



Key: (1) microwave
(2) metal plate
(3) antireflective microwave absorber

Figure 9. Construction of an Antireflective Microwave Absorber

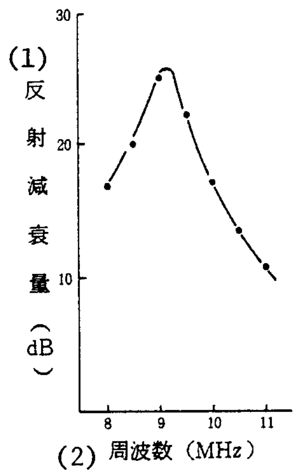
An antireflective microwave absorber is constructed, as shown in Figure 9, lined with a conductor such as a metal plate. It is necessary that the apparent values of electromagnetic properties of the free space be the same as the electromagnetic properties in the construction shown in Figure 9 (in order to prevent microwave reflection), which is fairly complex. The reflection coefficient, T, at the surface of the absorber, is given by the following equation:

$$\dot{T}_0 = \frac{\dot{T}_0 - e^{-2i\dot{\gamma}d}}{1 - \dot{T}_0 e^{-2i\dot{\gamma}d}}$$

where $\dot{T}_0 = \frac{\sqrt{\dot{\mu}/\dot{\varepsilon}} - 1}{\sqrt{\dot{\mu}/\dot{\varepsilon}} + 1}$ $\quad j = \frac{2\pi}{\lambda}\sqrt{\dot{\mu}\dot{\varepsilon}}$

in which $\dot{\mu} = \mu' - j\mu''$ $\quad \dot{\varepsilon} = \varepsilon' - j\varepsilon''$, and d is the thickness.

Consequently, when the thickness of the absorber, d, is made constant in the target frequency range, frequency characteristics of $\dot{\mu}$ and $\dot{\varepsilon}$ where $|T|$ is the minimum are necessary. In the case of composite ferrites in general, since the frequency characteristic of ε shows an almost constant value, material is selected in actual application by focusing on the frequency characteristic of $\dot{\mu}$. Figure 10 shows an example of the characteristic of an x - Band (9 GHz band) antireflective microwave absorber (the absorption characteristic is expressed with the attenuation for the reflection level of the metal plate). Compared with the reflection off the metal plate, attenuation of more than 20 dB (less than 1 percent reflection) is being obtained over a frequency range of 1 GHz or more. Figure 11 shows the frequency characteristic of the complex permeability of the microwave absorber. Not only the μ'' level but also the $\mu'\mu''$ characteristics in the 9 GHz band are attributable to the superior reflection attenuation shown in Figure 10.



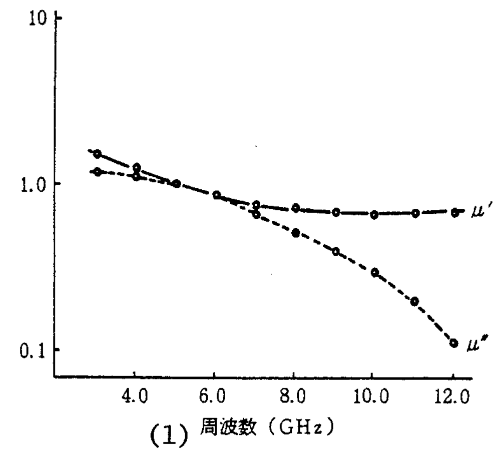


Figure 10. Example of Characteristic of an Antireflective Microwave Absorber Using Composite Ferrite

Key: (1) attenuation of reflection
(2) frequency

Figure 11. Frequency Characteristic of Complex Permeability

Key: (1) frequency

3. Trends in Composite Ferrite Microwave Absorbers

A composite material of chiefly rubber and ferrite was initially used for composite ferrite microwave absorbers. Subsequently, composites with resin have been produced, and today, composites with many organic materials are being produced. This is due to the fact that the chemical and thermal stabilities of composite ferrites are determined by the organic binding materials that are used as binders. Thus, various expansion has occurred with respect to materials, and many attempts are being made in manufacturing techniques as well.

Here, we shall discuss briefly the "manufacturing of composite ferrite by flame spraying" and "composite ferrite functional material" reinforced with glass fibers as recent trends for a composite ferrite microwave absorber.

3.1 Manufacturing of Composite Ferrite by Flame Spraying

Flame spraying is a method in which metal or resin in powder form is jetted out along with an arc, plasma, or flame from the tip of a nozzle so as to have it melt and adhere onto the substrate. It is in practical use today as a surface treatment for metals. On the other hand, the construction of a composite ferrite microwave absorber is frequently done to contain it in a metal frame and use it in contact with metal, both in the case of the antireflective microwave absorber lined with a metal plate and the microwave oven gasket used as an absorber to prevent microwave leakage.

The application of flame spraying to composite ferrites is conceivable as one of the methods to mount the material on a complex structure in order to simplify fabrication, fitting work, etc. Specifically, the idea is to form a composite ferrite coat onto a metal plate by jetting out a mixed powder compound consisting of a thermoplastic resin and ferrite powder, using flame spraying which is used in resin spraying. An example of the experimental approach is described below. The resins used were nylon 12 and polyethylene, and these resins and ferrite were sufficiently mulled in advance and then pulverized for use. A composite ferrite coat can be obtained by following the basic particulars for flame spraying, such as gas flow rate, temperature of the metal plate, and adjusting the distance between nozzle and metal plate.

However, the surface condition of the coat varies, depending on the amount of ferrite used and the particle size of the pulverized ferrite-resin mixture. For example, when ferrite was mixed with resin in volume ratios ranging from 10 to 60 percent and the pulverized particles were sprayed, the spray coat formed was flat without pinholes in the case of ferrite volume ratios of up to 35 percent.

Table 3 shows the ferrite mixing ratio and the specific gravity of the sprayed coat. The specific gravity of the sprayed coat is shown as the ratio to the theoretical value obtained from the mixing ratio of the coat. As is clear from this table, the specific gravity of the sprayed coat decreases as the volume ratio of the ferrite increases. This indicates that the number of pinholes in the coat is increasing. This is due to the fact that when the ferrite ratio in the resin increases, the viscosity of the resin upon melting increases and the resin does not flow on the metal plate, but deposits sediments on the metal plate, maintaining the form of the powder compound as shown in Figure 12.

Table 3.

Composition (volume ratio)	40 percent	50 percent	60 percent
Specific gravity	92 percent	88 percent	72 percent

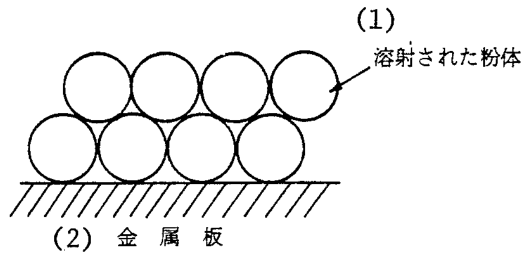
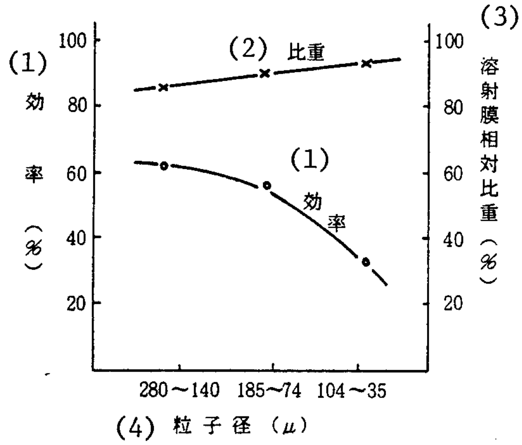


Figure 12. Structure of Sprayed Coat When Particles With High Ferrite Content Were Sprayed



Key:
(1) efficiency
(2) specific gravity
(3) relative specific gravity of the sprayed coat
(4) particle size

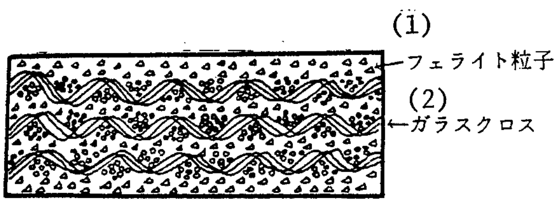
Figure 13. Relationship of Sprayed Particle Size to Efficiency and Specific Gravity of the Sprayed Coat

Meanwhile, the effects of the particle size of the powder compound on the sprayed coat were examined, and the results are shown in Figure 13. Particle size affects both the specific gravity of the sprayed coat and spray efficiency. One way to form a sprayed coat with fewer pinholes is to reduce particle size. Favorable results were obtained in the formation of a composite ferrite coat when the mixing ratio of the ferrite was less than 35 percent in volume ratio. A practical application is awaited for the antireflective microwave absorbers in the microwave band.

As discussed previously, composite ferrite microwave absorbers are being used in various ways. As usage expands, not only the microwave absorption characteristics but also various kinds of durability have become necessary. For example, they include durability against heat aging in the case of an absorber for preventing microwave leakage used in microwave ovens, weatherability for outdoor use and mechanical strength for mounting onto a structural part in the case of

microwave absorbers for preventing the reflection of microwaves, and so forth. In response to these requirements, the type of resin or rubber used as the binders has been varied, but no fundamental solution has been achieved in respect to mechanical strength. Particularly when the ferrite content is high, the strength often decreases, even to a value lower than the original strength of resin or rubber. In order to increase the strength of composite ferrites and endow the function of a structural material, a composition with glass fibers or carbon fibers has been attempted recently. Composition of glass fibers and resin has been practiced for a long time and is widely used as FRP. This technique is being applied to improve the strength of composite ferrites.

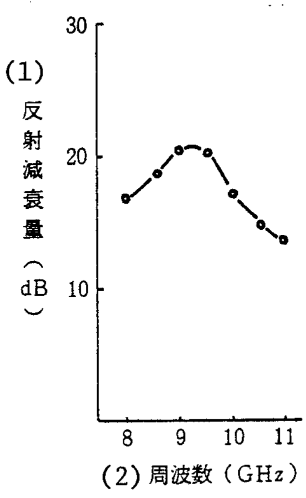
This attempt began recently, and studies are being carried out as to the electrical characteristics, mechanical strength, etc., of the antireflective microwave absorbers that can be used as a structural part. Figure 14 shows a cross-sectional diagram of the composite ferrite absorber using glass cloth, currently under investigation. The structure is ferrite powder scattered between layers of glass cloth.



Key: (1) ferrite particles
(2) glass cloth

Figure 14. Structure of Microwave Absorber Structural Material
(Resin is epoxy resin)

By forming this structure, a composite ferrite having a flexural strength of more than 20 kg/mm^2 has been obtained. Figure 15 shows the characteristic curve of a microwave absorber for preventing microwave reflection, which was built with a composite ferrite having this structure.



Key: (1) attenuation of reflection
(2) frequency

Figure 15. Characteristic Curve of an Antireflective Microwave Absorber Made of Microwave Absorber Structural Material

When the amounts of glass, resin, and ferrite powder are controlled, more than 20-dB attenuation of reflection is obtained. However, in order to control the amounts of these three components, it is necessary to add a new element to the FRP manufacturing technique used thus far, and the problems remaining for the future are extensive.

4. Conclusions

Ferrites (soft ferrites), which played a big role in the development of the electronics industry as high-frequency, low-loss, core materials, are being reevaluated as new microwave absorbers associated with the versatile use of microwaves in today's progress in electronics equipment and consequent production of unnecessary microwave reflections leading to microwave pollution. In view of the operational principle of microwave absorbers and the high-frequency magnetization mechanism of composite ferrites, they are among the most promising materials for microwave absorption to be used for microwave-pollution countermeasures by controlling the material constant. If it becomes possible to provide a functional material by further induction of new composite technology, we believe that an immeasurable range of applications exist, including structures that handle microwaves--not to mention electronics equipment.

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